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Effect of Phosphate on Gelatinization of Rice Starch

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인산염이 쌀전분의 호화에 미치는 영향

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Abstract

Effect of phosphate (sodium polyphosphate 85%, sodium hexametaphosphate 7% and potassium phosphate 7%) on gelatinization of nonwaxy and waxy rice starches was investigated with X-ray diffractometry. The minimum moisture content for the gelatinization of nonwaxy starches was lowered in the presence of phosphate. The minimum temperature for the gelatinization of 5% starch suspensions was not altered by phosphate. However, the degree of gelatinization of rice starches at the same temperature was higher in the presence of phosphate, except waxy rice starch.

Introduction

Phosphates have been widely used in food processing.[1,2] The use of phosphates in starchy food products is scarce however. Nara *et al.*[3] demonstrated that sodium pyrophosphate had a greater effect in retarding the swelling of potato starch granules and thus depressing viscosity of the starch pastes. Recently, Kim and Kim[4,5] reported that phosphates slowed down the firming rate of nonwaxy cooked rice by reducing the amount of starch components available for crystallization.

The purpose of this study was to investigate the degree of gelatinization of rice starch in the absence or presence of phosphate.

Materials and Methods

Materials

Nonwaxy varieties of a Japonica type (Akibare) and an Indica type (Milyang 30) and a variety of waxy rice were dehulled and abrasively polished 8% by weight.

Phosphate, obtained from Seo-Do Chemical Co., Ltd., Seoul, is composed of sodium polyphosphate (85%), sodium hexametaphosphate (7%) and potassium polyphosphate (8%).

Determination of degree of gelatinization

Standards representing 0—100% gelatinized starch were prepared. Raw starch was used to represent the 0% gelatinized sample. The 100% gelatinized sample was prepared by autoclaving the 2% starch suspension at 120 °C for 1 hr, followed by vaccum drying and grinding to pass through a 200-mesh screen.

The degree of gelatinization of the standard samples ranging from 0 to 100% gelatinization were analyzed by X-ray diffractometry using a built-in internal standard approach.[6] The ratio of the decrease in peak heights of the internal standard and the component (peak at diffraction angle of 22.8°) was plotted against the degree of gelatinization of the test samples to obtain a standard curve.

Determination of moisture requirement for gelatinization

Distilled water was added to raw starch in the absence or presence of phosphate to produce a series of samples with moisture contents of 30—70%. The concentration of phosphate used was 0.3% (w/w). Phosphate was dissolved in water prior to use. The samples were retorted at 120 °C for 1hr, followed by vaccum drying and grinding. The extent of gelatinization was analyzed by X-ray method and calculated from the standard curve.

Determination of gelatinization temperature

The starch suspension (5%) in the absence or presence of phosphate (0.3%, w/w) was heated to desired temperature, dehydrated with ethanol and vaccum dried. The degree of gelatinization was determined as described previously.

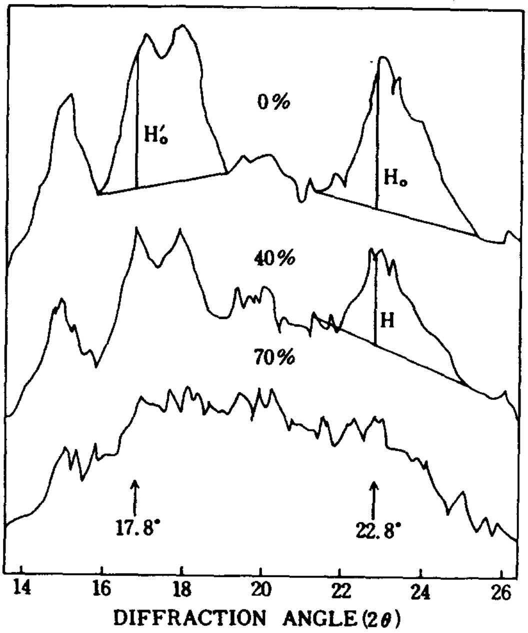

Fig. 1. X-ray diffractogram for mixtures of 0~100% gelatinized standard Akibare starch samples

H' = peak height of raw starch initially used as internal standard: H_0 = peak height of raw starch used as internal standard; H = peak height of starch undergoing gelatinization

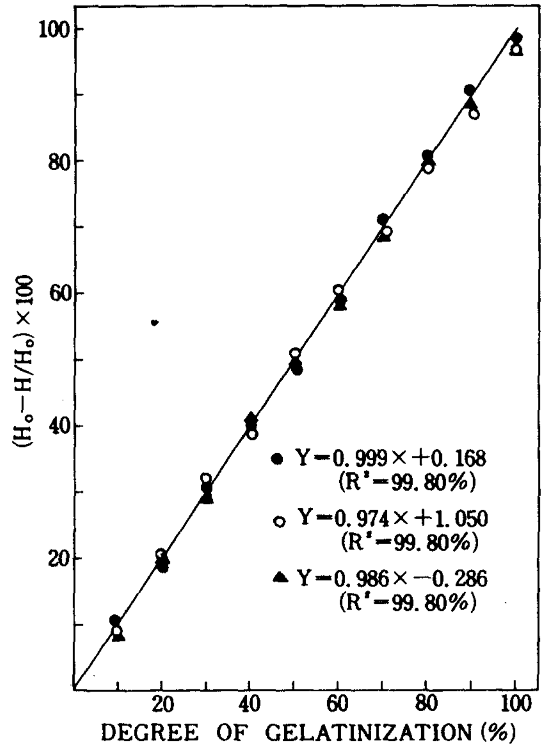

Fig. 2. Percent ratio of X-ray peak decrease for mixtures of 0-100% gelatinized Akibare (●), Milyang 30 (○) and waxy (▲) rice starch samples

Results and Discussion

X-ray diffractogram for mixtures of gelatinized standard Akibare starch samples is shown in Fig. 1. The crystallinity of the starch decreased as gelatinization increased. When the decrease in peak height of a component of the native starch (0% gelatinization) as the built-in internal standard was related to the original peak of this component, a linear relationship was obtained between the decrease in crystallinity and the degree of gelatinization (Fig. 2). The correlation coefficient (R^2=99.80%) was similar to that reported for corn starch.[6]

The percent decrease in X-ray peak height of rice starch increased with moisture content (Fig. 3). These decreases were more pronounced in the presence of phosphate, except waxy rice starch. A critical moisture content was observed, after which no appreciable decrease in peak heights was found as the moisture content increased. No further decrease in crystallinity may indicate the complete gelatinization of starches. Thus, below 43% (Akibare) and 45% (Milyang 30 and waxy) moisture, the starches might have been partially gelatinized. The minimum moisture contents for gelatinization of rice [7] and corn[6] starches are about 45% and 47%, respectively.

As evident in Fig. 3, the minimum moisture contents for Akibare and Milyang 30 starch were about 40% in the presence of phosphate. These results indicate that phosphate has a definite effect in enhancing the gelatinization of nonwaxy rice starches, with more pronounced effect on Milyang 30. Phosphate exerted no effect on the gelatinization of waxy rice starch.

The degree of gelatinization of 5% starch suspensions at various temperatures in the absence or presence of phosphate is presented in Table 1. The minimum temperature for the gelatinization of nonwaxy rice starches was 70 °C, while that of waxy rice starch was 65 °C. Although the minimum tempereture for the gelatinization of the starches was not affected by phosphate, the degree of gelatinization of nonwaxy rice starches at the same temperature was higher in the presence of phosphate.

From the results in Fig. 3 and Table 1, it can be concluded that phosphate had a definite effect in nonwaxy

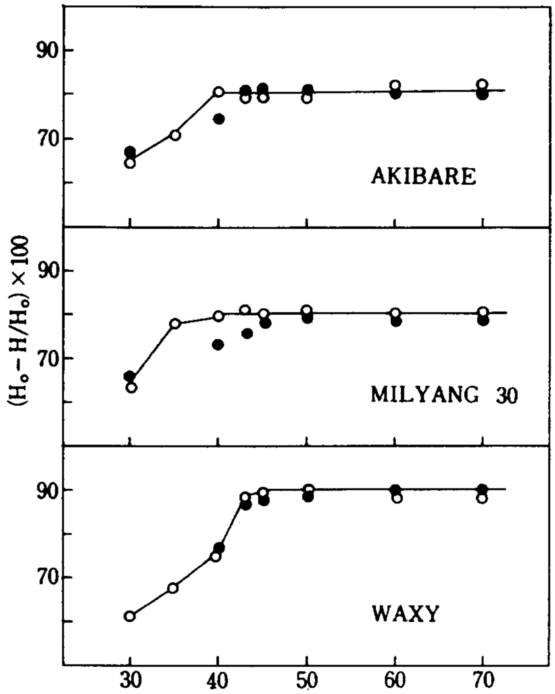

Fig. 3. Percent decrease in X-ray peak height as a function of moisture content of rice starches in the absence (●) and presence (○) of phosphate

rice starch gelatinization. It was reported[6,8,9] that amylose-amylopectin ratio plays an important role in starch gelatinization. The high amylose component could have bound much of the water so that only after higher moisture levels had been attained did any appreciable gelatinization take place. The amylose contents for Akibare and Milyang 30 starch are 18.5 and 18.9%, respectively. It is thus remained to be elucidated as to why phosphate exerted more pronounced effect in enhancing the gelatinization of Milyang 30 starch than Akibare starch.

요 약

인산염이 쌀전분의 호화에 미치는 영향을 X－ray 회절법으로 조사하였다. 인산염은 멥쌀전분의 호화에 필요한 수분을 감소시켰다. 5% 멥쌀전분 현탁액의 호화온도는 인산염에 의하여 영향을 받지 않았으나, 같은 온도에서는 인산염의 존재시 호화도는 높은 값을 보였다. 인삼염은 찹쌀전분의 경우 호화에 영향을 미치지 않았다.

Table 1. Degree of gelatinization of 5% starch suspensions at various temperatures in the absence or presence of phosphate

	Temp.	Degree of gelatinization (%)	
	(°C)	Control	With P
Akibare	30	0	0
	50	12.0	15.4
	55	14.7	16.0
	60	20.0	23.1
	65	73.3	79.5
	70	90.7	92.3
Milyang 30	30	0	0
	50	12.5	16.3
	55	15.1	18.6
	60	25.6	30.2
	65	76.7	83.7
	70	93.0	95.2
Waxy	30	0	0
	50	15.5	15.7
	55	20.7	21.2
	60	42.3	47.1
	65	95.2	94.2
	70	94.5	95.2

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